OBSERVATIONS ON SOIL SALINITY AND QUALITY

OF

IRRIGATION WATER IN SEVERAL PARTS OF CUBA

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Alvin D. Ayers

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United States Salinity Laboratory
Soil and Water Conservation Research Branch
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Riverside, California
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FOREWORD

The Banco de Fomento Agrícola e Industrial de Cuba has started a semidetailed soils map under the direction of H. H. Bennett. In conjunction with this work and because of continued reports of salinity damage to crops, it was deemed desirable to make a preliminary investigation as to the actual occurrence of salinity and its possible extent and severity.

The Foreign Operations Administration has a special contract with the Agricultural Research Service of the U. S. Department of Agriculture whereby certain services of the U. S. Salinity Laboratory, Riverside, California, are available. It was through this contract that A. D. Ayers, Soil Scientist on the staff of the Salinity Laboratory, was assigned to the U. S. Operations Mission to Cuba for sixty days during January, February, and March 1955 to study the salinity problem.

SUMMARY

During the assignment, trips were made into the provinces of Havana, Pinar del Río and Camagüey. Serious salinity damage to cultivated crops was noted only on rice and this occurred only in a few areas. The salinity hazard may increase with the continued use of large quantities of poor quality (saline) irrigation waters on lands with relatively impermeable subsoils.

In certain areas, the salt content of the irrigation waters from wells increased as the distance to the coastal swamp decreased. This increase in salinity was caused primarily by an increase in sodium chloride ($NaCl$).

It has been reported by the growers that some wells near the sea have become more saline with time and a number of wells have been abandoned because of increasing or high salt concentrations.

Absence of grain in the rice panicles resulted in low yields in fields harvested in January, February, and March 1955. These low yields could not be correlated with any general salinity condition in the soil or irrigation water. Minimum temperatures were as low as 8° to 10° C. during parts of December, January, and February and may have been the major causative factor.

In the production of irrigated crops on soils underlain by thick, slowly permeable, plastic, clay layers, management may find that it will be necessary to adopt practices which tend to minimize possible salt accumulation.

Salinity determinations were made on over fifty soil samples and on over one hundred water samples. The results of these analyses are attached. Particular attention is called to the water samples on which detailed analyses were made. There appear to be no widespread, abnormal, ionic relationships in the irrigation waters.

Future studies should be arranged so that the effect of increased or continued pumping on water quality and levels can be determined.

In order to have a firmer basis for a stable industry, more information is needed on soil, water, climate, nutrition, and management practices as they affect rice production under conditions in Cuba.

INTRODUCTION

All plants require small amounts of certain mineral salts for proper growth. If these same essential salts, or any other salts, 1/ occur in high concentrations, they will decrease or inhibit plant growth. Soils or waters are said to be saline when the salt concentration in a soil or an irrigation water applied to it is high enough to have a harmful effect on crop production (10).

During the years 1954 and 1955 there were a number of reports by growers of salinity damage to crops. Saline soils and waters were reported by Bennett and Allison (1) in 1928, and the effect of salinity on rice was the basis of research by del Valle and Babé (11) in 1947. All the coastal swamps are more or less saline and some wells drilled in the adjacent lowlands have undesirably high salt contents.

In the last five years, there has been a large increase in the acreage of irrigated crops and in the number of wells developed for irrigation. Part of this development, particularly for rice, has been in the coastal plains where subsoil drainage is frequently poor. Irrigation wells in the lower part of the coastal plain, or close to the coast, sometimes produce waters with a high to very high salinity hazard rating.

Farm operators had been alerted to the possibility of salt accumulation and in several locations symptoms similar to those caused by salt had been observed. This led some farmers to attribute unexplained poor crop yields to salt injury.

The objective of the present assignment was to obtain factual information on the extent and seriousness of the salinity problem.

1/ In this report, the term salt refers to any mineral salt found in the soil or water and is not limited to sodium chloride, the common table salt.

Because of the short time available, investigations were limited to the areas which reported possible salt damage. These included the southern parts of Havana and Pinar del Río provinces and a portion of Camagüey.

OCCURRENCE OF SALINITY

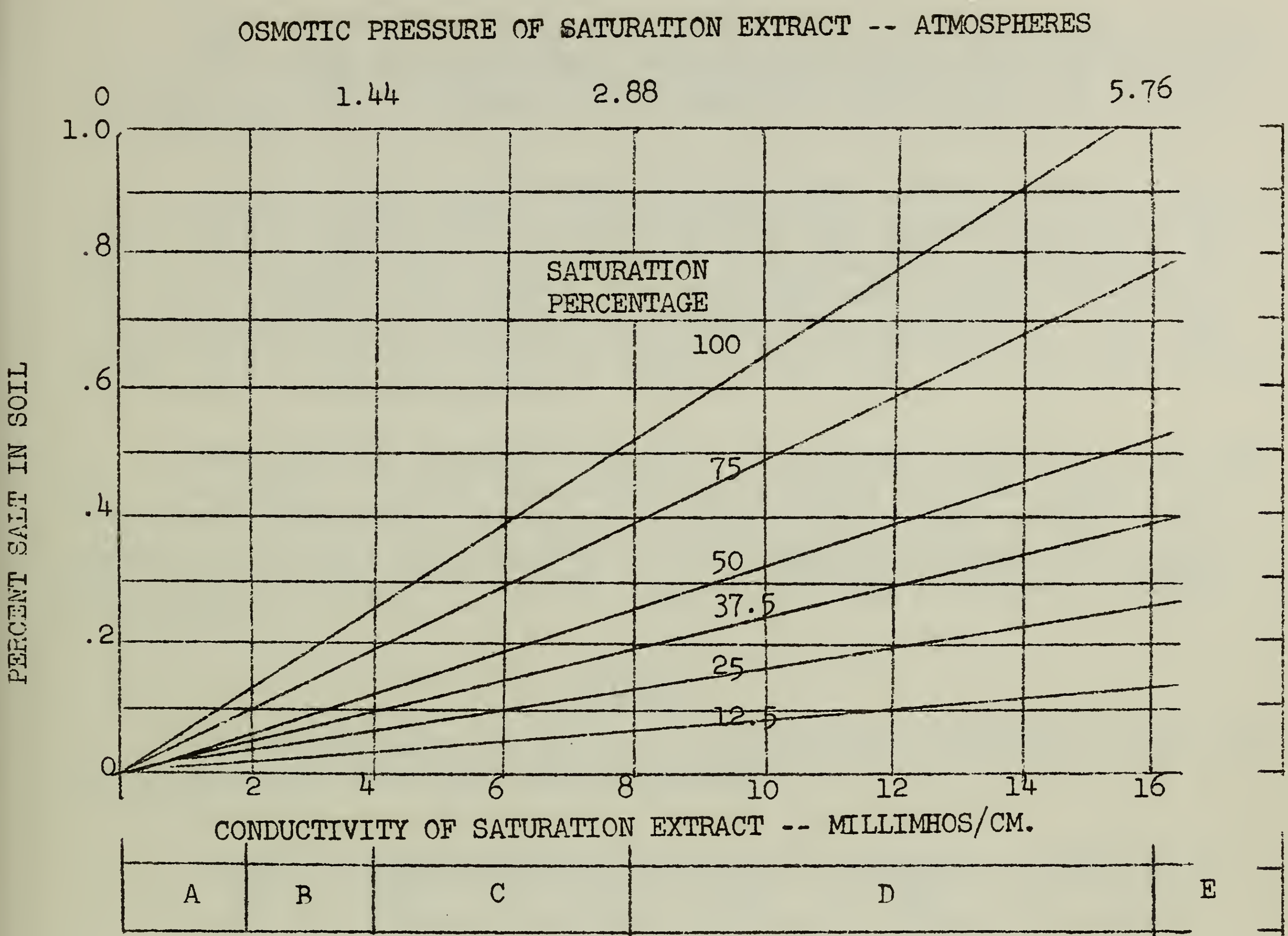
The coastal swamps show the influence of sea water. Samples S-5, -6, -7, -8, -9, -46, W-22 and W-45 were taken at the border of the swamp and the cultivated areas, and are representative of the transition from the non-saline agricultural lands to the more saline coastal swamps. W-46 was a sample of the soil solution close to the beach and is indicative of the higher salt levels to be found nearer the coast. Salinity probably also affects some of the grasslands adjacent to the swamps. S-39 was an extreme example of such an area and was almost devoid of vegetation because of salt. The present study, however, was devoted almost completely to cultivated lands. No work was done in areas of serpentine soils, reported to be high in both soluble and exchangeable magnesium.

No serious salt damage was observed on any cultivated crop except rice. Most irrigated crops, other than rice, are grown on fairly permeable soils, and salinity does not appear to be a serious factor because of good drainage, high annual rainfall, and the use of a relatively good quality of irrigation waters.

For example, fair banana plants were being grown under irrigation on Matanzas clay using a relatively saline water. This irrigation water (W-23) had a conductivity of 4.4 millimhos (2600 parts per million of total salts), yet there was only 0.1 percent salt in the 0-6 inch layer of soil and the saturated soil extract had a conductivity of only 2 millimhos indicating a non-saline soil (10). Because of satisfactory permeability, the use of adequate amounts of irrigation water, and an annual rainfall of 40 to 50 inches, excessive amounts of salt were not present when sampled in the dry winter season.

A later section is devoted to the occurrence of salinity and the salinity hazard in the production of rice.

The U. S. Salinity Laboratory uses the conductivity of an extract from a saturated soil paste as a measure of soil salinity (10). The relative salinity scale and the relationship between conductivity and percent salt for soils of different textures are shown in figure 1.



A	B	C	D	E
Salinity effects mostly negligible	Yields of very sensitive crops may be restricted	Yields of many crops restricted	Only tolerant crops yield satisfactorily	Only a few very tolerant crops yield satisfactorily

0 2 4 8 16

Scale of conductivity (millimhos per centimeter at 25°C.)

Figure 1. Relation of the percent salt in the soil to the osmotic pressure and electrical conductivity of the saturation extract and to crop response in the conductivity ranges designated by letters.

QUALITY OF IRRIGATION WATERS

The expansion of irrigation for all crops is continuing at a rapid rate. This expansion has utilized water pumped mostly from the underground but there is also an increase in the amount of water pumped and diverted from streams.

At least three reports were obtained which stated that wells had been abandoned because of an increase in the salt content of the irrigation water. In one area, about 20 wells had been abandoned. Other wells in this area sometimes were pumped only until the salt content increased to a predetermined level and then were "rested" for several days. One man stated that in order to keep the salinity level low, he could pump certain wells only at reduced capacity.

Water quality sometimes changes with distance of the well from the sea. Near Güira, samples were taken from a series of wells located in a north-south direction inland from the edge of the coastal swamp. Conductances, or total salt content, showed a definite decrease in salinity with distance of the well from the coast. The data are shown in figure 2 and table I.

TABLE I

Salinity in parts per million of total salts and depth as well location approaches the coast, Güira Municipio.

Well No.	Depth 1/ Ft.	Total Salts p.p.m.	Well No.	Depth 1/ Ft.	Total Salts p.p.m.
35	110/250	269	28	24/70	396
34	82/40	228	27	13/40	832
32	81/87	290	26	20/--	630
31	60/90	312	25	6/24	1088
30	36/42	352	24	6/12	1792
29	26/42	416	23	6/12	2604
			22	Boat channel	2042

1/ Depth to water table/total depth of well.

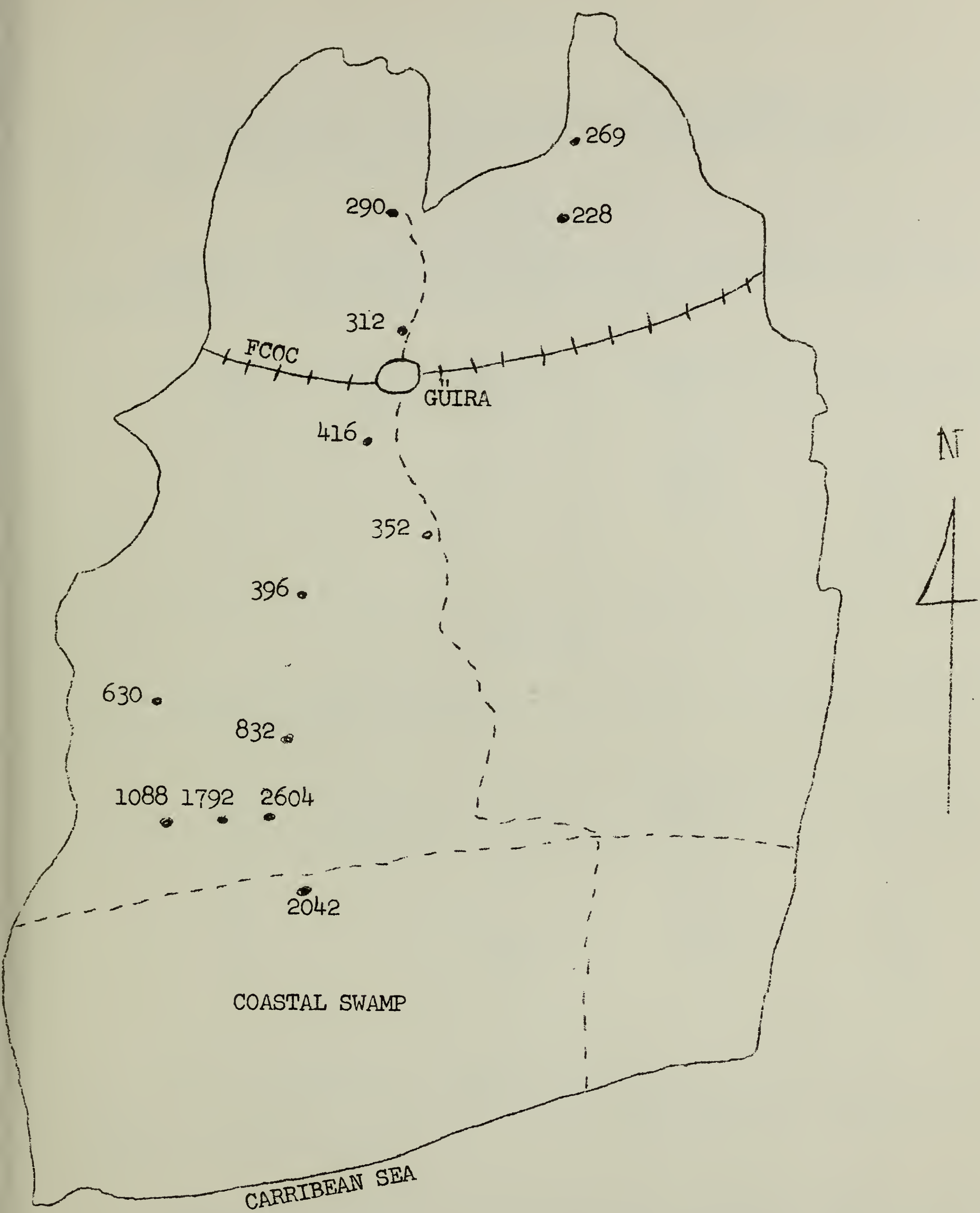


Figure 2. Salinity of wells in parts per million with distance from coast, Güira Municipio, Habana Province, Cuba.

Similar, but less extensive, data given in tables II and III show this same relationship in San Cristóbal and Candelaria Municipios as wells are located closer to the coast.

TABLE II

Salinity of a group of irrigation wells approaching the coast in a north-south direction in San Cristóbal Municipio.

Well No.	Miles south of San Cristóbal	Depth 1/ Ft.	Total Salts p.p.m.
1	1	12/21	576
3	7	20/42	640
4	10	40/150	928
5	10	-	1114
6	15	-	2048

TABLE III

Salinity of several wells approaching the coast in a north-south direction in Candelaria Municipio.

Well No.	Distance south of highway in miles	Depth 1/ Ft.	Total Salts p.p.m.
91	1/16	110/150	371
90	1	72/110	390
42	6 (S&W)	38/110	640
88	7 (S&E)	3/145	704
43	10	-	800

Data on topography and ground-water levels is scanty but there are isolated measurements which indicate that water levels in many of the wells near the coast are at about sea level and that water is being pumped from aquifers below sea level.

There seems to be little available information in Cuba on water quality and water-table levels. These are subjects in which the Cuban government should take more interest because the foregoing data indicate the possibility of salt water intrusion if there is a continued overdraft on the underground water.

1/ Depth to water table/total depth of well.

The U. S. Salinity Laboratory (10) has proposed a general classification of waters for irrigation use. This scheme is shown in figure 3 and is very useful for the relative evaluation of water quality from both the salinity and the sodium hazard. The salinity of the waters tested ranged from low to very high, but the majority had a medium to high salinity hazard. More complete analyses of selected samples showed low to medium sodium (alkali) hazard ratings. The classification of these waters is also shown in figure 3.

Detailed analyses were made of 37 water samples collected from wells and streams in the areas visited and are given in Rubidoux Unit Table 8/55 and 24/55 which are attached as a part of this report. No abnormal ionic relationships were found. The less saline samples are characteristic of the type of waters which one would expect to find where limestones are present. Those samples with higher total salt contents had higher concentrations of sodium and chloride. No excessive amounts of boron were found. The detailed analyses of these 37 waters were made on samples shipped to the Rubidoux Unit of the U. S. Salinity Laboratory at Riverside, California. Alkalinity (pH) of these samples were higher at the time of the analyses than at the time of sampling and the pH values given in the table on Water Data should be used to characterize the water supply.

Salinity and sodium are more likely to be a problem when irrigation waters of questionable quality are used on poorly drained, fine-textured soils than when used on medium to coarse-textured soils with good surface and subsoil drainage. High rainfall, such as the 40 to 50 inches occurring in Cuba, is favorable for reducing both the salinity and sodium hazard.

It is difficult to set a definite salinity limit above which water is not safe for use. The aforementioned factors of soil, rainfall, crop, drainage, and management are modifying factors which must be taken into account. The U. S. Salinity Laboratory method, however, does provide a means of rating the waters on a relative probability basis. Such ratings become even more useful when correlated with field experience and observations for the crop and area concerned.

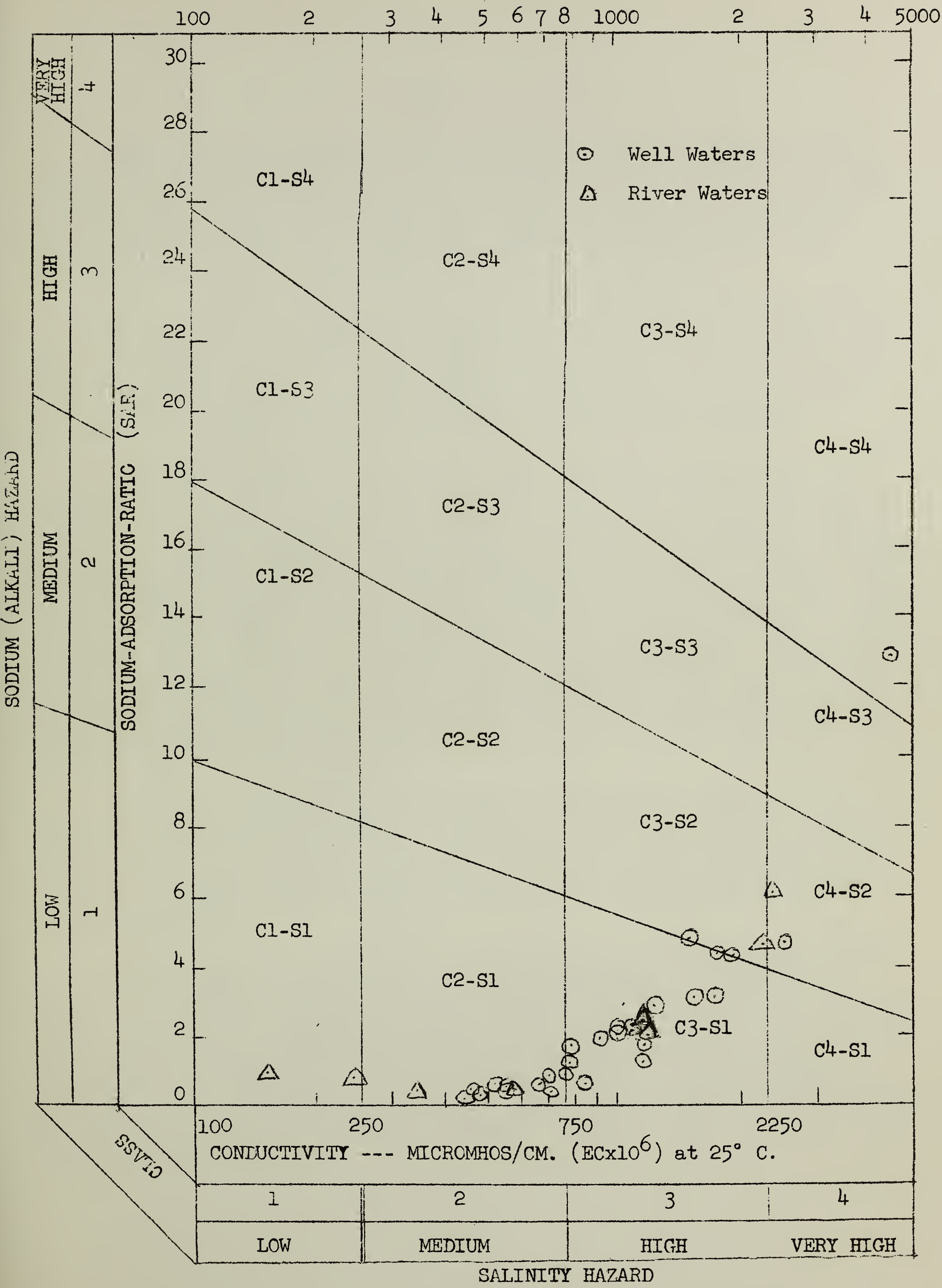


Figure 3. Diagram for classification of irrigation waters.

RICE

Rice will be discussed in more detail because (a) severe salinity damage was observed in several fields, (b) some irrigation waters of questionable quality are being used, (c) the assumption that salinity was causing widespread damage to this crop, and (d) the special soil conditions under which rice is grown. Points made concerning rice, however, are applicable to any other crop grown under similar conditions.

Rice is a staple in the Cuban diet and up to a few years ago, most of it was imported. With the high price of rice on the world market, the desire to conserve on imports, and the need to diversify the agricultural program to replace cuts in sugar acreage, it was logical that rice should receive particular attention. When the first expansion onto cheap land appeared to be highly profitable, further expansion was stimulated.

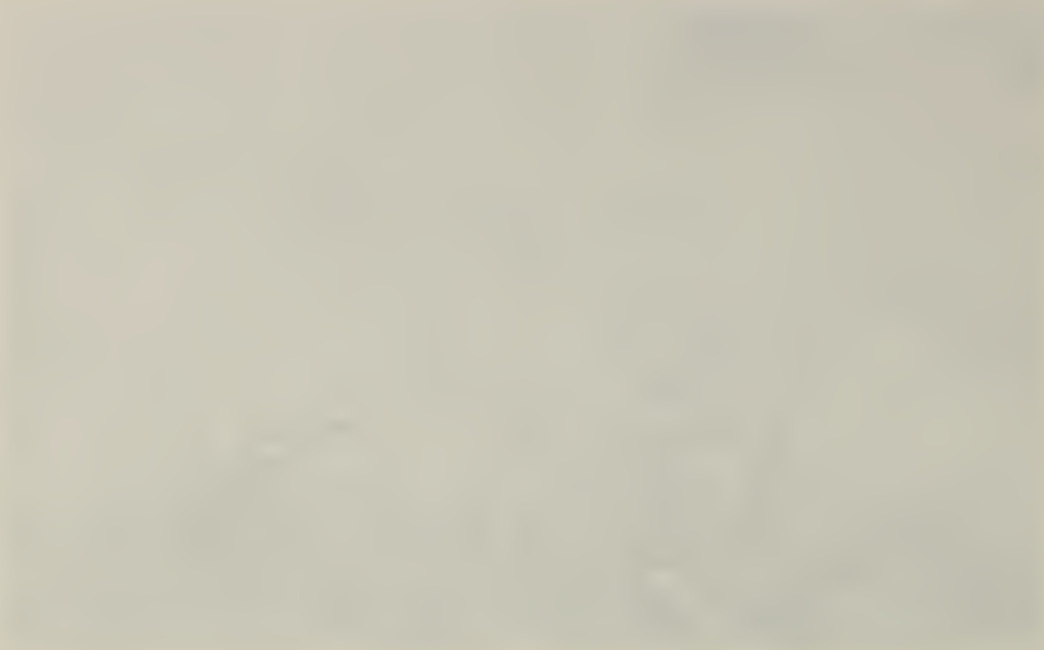
This large expansion in rice acreage took place after a very short experience period and without any appreciable previous or accompanying research. In December 1954, it was observed that rice being harvested was giving low yields. Later, investigations showed that the heads or panicles approaching maturity were frequently almost devoid of grain. Figure 4 shows the type head encountered. This loss of a portion of the winter crop immediately raised questions regarding the production of rice in the winter season, growing more than one crop per year, a possible need for fallow and/or rotations, and the salinity hazards which may be encountered. These and other factors should be given serious consideration by the rice industry and governmental agencies interested in making rice a stable crop in the agricultural program of Cuba. This discussion is concerned only with the salinity hazard in rice culture.

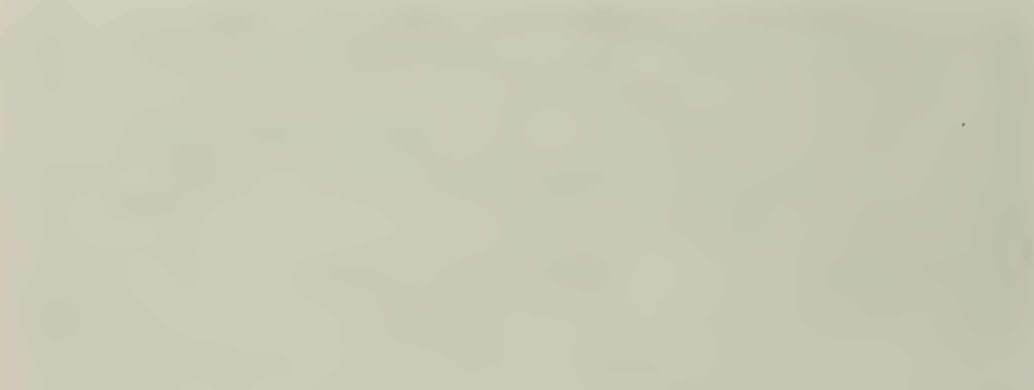
Rice is flooded for the major part of the growing period and so requires large amounts of water. In order to assure the economic use of water, lands are selected which allow little loss of water by deep percolation. The sandy Savannah and clay soils of the coastal plain which are underlain by thick beds of dense, plastic, almost impermeable clay meet this requirement.

Salt, which is present in various amounts in all irrigation waters, may be concentrated in the root zone by transpiration and evaporation. Such a concentration cannot be readily washed out of the root zone of these soils because their impermeable, dense, thick, clay subsoils limit the downward water movement. If this salt is not carried away by subsoil drainage or surface flooding faster than it is concentrated, it will continue to accumulate until it will have a harmful effect on crop production. Apparently, this has happened in several instances. Figure 5 shows salinity damage in a field near Batabanó.

Figure 4. Upright heads of rice almost devoid of grain. Normally filled heads are bent over in an arch by the weight of the grain and none are visible in the figure.

Figure 5. Salt damage to rice near Batabanó in Havana Province.





Besides the effects of subsoil permeability or drainage, rate of salt accumulation may also be dependent upon the total amount of salt applied per year. That is, it is dependent upon the amount of irrigation water applied and upon the concentration of salt in that water. Growing rice under present conditions and present management practices favors the possibility of salt accumulation. Rice has frequently been grown continuously; and this has often been not just one crop a year without a rotation, but as many crops per year as can be planted and harvested and for as many years as production will be profitable. This practice requires a maximum application of irrigation water and accompanying salt per year, a minimum percentage use of salt-free rain water, and the practical elimination of any normal leaching period.

This possibility of salt accumulation is further intensified in some cases by the use of poor quality irrigation waters. In several areas, wells located near the sea or near the coastal swamps have a considerable salt content. Conductivities of waters tested ranged up to two or two and a half millimhos. This is equivalent to about 1200 to 1500 parts per million of total salts, or up to two tons of salt per acre for each foot of irrigation water applied.

One rice grower in Havana Province and one in the Province of Pinar del Río reported severe salt damage. Several of their fields had spots which were completely devoid of rice and on which salinity was visible on the soil surface. In parts of the fields, the rice plants varied in size from none to poor to good. This spotty distribution, with barren spots only a few feet from good plants, is characteristic of saline conditions and salt injury. An example of this salt damage is shown in figure 5.

Actual salt levels in soils from the affected areas described ranged from 0.06 to over 0.4 percent salt in the surface eight inches, EC_e of 3 to 8 millimhos, (S-27, -30, -49). In one instance, the surface half-inch of soil contained 1.7 percent salt (S-48). Appreciable amounts of salt were also found in most of the subsoil samples (S-28, -29, -50, -51).

Salt damage was not reported to have been present in the above fields the first year but was clearly evident the second year. The well (W-52) in Havana Province, supplying water for one of the fields, had a conductivity, at time of sampling, of 1.7 millimhos, or about 1000 parts per million of total salts. At the other locations, the conductivity of wells used ranged from 1.8 to 2.6 millimhos, or total salts of about 1100 to 1600 parts per million (W-56, -60, -61).

Not all growers using waters of the above concentrations have reported salt injury. Samples S-35 and S-41 show some salt accumulations from the use of irrigation waters in this questionable range, but no crop injury had been noted. Future salt contents and crop responses should be closely watched wherever poor quality waters are being used. Growers south of Herradura have reported that rice land must be fallowed after 2 or 3 years because of reduced yields which they attributed to salt accumulation.

The accumulation of salt in rice lands can be minimized by following certain management practices. For example:

1. Growing the crop only in the rainy summer season and making maximum use of the non-saline rain water.

2. Growing fewer crops per year and thus applying less total irrigation water and salt. This also allows some time for normal leaching.

3. Rotation with a non-irrigated crop or inclusion of a fallow period to allow natural leaching of accumulated salt.

4. Use of irrigation waters having low salinity levels.

"Straight head" is a term used in Cuba to describe a lack of grain in the head so that the head stands up straight rather than bending over from the weight of the grain. See figure 4. Fields in head and ready for harvest in January, February, and March of this year were severely affected. It is doubtful if this absence of grain in the heads of rice in the winter of 1954-55 could have been caused by soil salinity because:

1. At the time of this study, no appreciable salt concentration was found in any of the fields suffering from this so-called "straight head".

2. Not a single field which was in head in January or February had escaped serious crop reduction. The conditions were observed in fields from Camagüey in the east-central to Guane in the western part of the island.

3. This condition was observed on sandy Savannah-type soils, clay soils, and in fields irrigated from wells and from river waters. It also occurred in first-year rice and in fields planted to rice for the second or third year.

4. Rice harvested in December was more seriously affected than that harvested in November. Yields for January were reported to be poorer than those for December, and February yields will be at least as low as those for January. March yields also are likely to be low.

5. Rice plants approaching maturity, as well as those in head, had many dead roots, and the tops usually had an unthrifty, yellow appearance. Even some of the young plants and some weeds had dead roots.

SALT TOLERANCE OF RICE

Rice has been classed as having a moderate tolerance for salinity (10). This has been based on observations that rice is often grown on saline lands which are being leached. This use of rice as a leach crop is quite common in India, Pakistan, and several other countries (4). Actual experimental work on the effect on rice of varying levels of salinity in soils and irrigation waters is limited.

In an early paper, Fraps (2) concluded that water containing 0.3% salt was dangerous to use on rice, that water containing less may be dangerous, and that water containing 0.5% should not be used for irrigation. From additional work at a later date (3), he pointed out that water containing smaller amounts of salt may be injurious if used for some time and advised against using water containing over 40 to 50 grains per gallon--684 to 855 parts per million. These concentration figures were for sodium chloride based on a chloride titration and total soluble salts would have been somewhat higher.

Quereau (8), working in Louisiana, published a bulletin in 1920 with the following conclusions:

"(1) Do not use water containing more than 35 grains per gallon of salt 1/ (600 p.p.m.) in a flooding of from 4 to 8 inches if this amount of salt water is to remain on the field until it evaporates or is diluted with fresh water.

(2) Do not flood a second time with water containing more than 15 grains of salt per gallon (257 p.p.m.).

(3) It may or may not be harmful to use water containing 50 grains (855 p.p.m.) of salt on land which is wet prior to the application of the salt water, when it is possible to remove all of the salt water and replace with fresh water within two weeks of the time that the salt is applied."

Peevy (6) found little difference between the effect of $NaCl$ and $CaCl_2$ in waters and obtained some damage when pots were irrigated with water containing 37 grains per gallon, 633 parts per million, but damage depended upon the stage of growth when the salty water was applied. He included the following table which was used by the Canal Companies and many growers in Louisiana as the limiting salt concentration allowable in canal waters.

1/ 1 grain per gallon equals 17.1 parts per million.

Stage of growth	Days after emergence	Tolerance in grains per gallon	
		Blue Rose	Early Prolific
Tillering	20- 40	75-100	75-100
Jointing	40- 70	75-100	140-175
Booting	70- 90	200-250	175-200
Heading	90-100	250-275	200-225

The Louisiana work, like that of Texas, was based on a chloride titration and calculated as sodium chloride.

Field and greenhouse experiments in Arkansas (5) showed that NaCl in the soil would delay and reduce germination of rice. As little as 825 lbs. of NaCl applied to the soil surface prior to irrigation had a significant harmful effect.

Del Valle and Babé (11) grew rice in pots and watered it with various concentrations of sodium chloride when the rice was 30, 60, and 90 days old. A concentration of 0.15 percent (1500 p.p.m.) lowered the yield of rice when the saline water was applied to 30 day-old rice. Older rice was less sensitive.

Stromberg and Yamada (9) observed that rice near the irrigation inlet was better than that in the rest of several poor fields in California. As water passed over the soil, its quality was altered by picking up salts, by evaporation and by transpiration. When the analyses of the waters were plotted, it was found that waters from the poor fields were high in salts or high in percent of sodium. These data were supplemented by growing rice in nutrient solutions with varying salt concentrations and sodium percentages. The good plants were correlated with waters having a total salt content of less than 500 to 1500 parts per million of total salts when the sodium percentage ranged from 90 to 5 percent. Increasing total salt concentration or sodium percentage had a detrimental effect.

Ponnamperuma, Bradfield, and Peech (7) reported a physiological disease attributable to iron toxicity. The symptoms described did not correspond to either the "straight head" or salinity damage observed in the field. However, the rice lands of Cuba often contain concretions high in iron and the possibility of iron injury should not be overlooked.

One can see that the various investigations using several experimental methods, varieties, environmental, and cultural conditions have all agreed that salinity is harmful to rice production. They have not, it is true, come

up with identical, safe, permissible limits, as their conditions and objects were not always the same. For example, when water is used for the entire growth period, lower levels of salinity will be more harmful than higher salinity waters used only intermittently or only during the latter part of the growing season.

In reviewing the foregoing experimental work, it appears that:

(a) Irrigation waters below 500 parts per million total salts should be considered safe for use and to be of good quality;

(b) Waters having over about 1500 parts per million total salts should be considered to be of definitely poor quality; and

(c) The hazard of using those waters in the intermediate range of 500 to 1500 parts per million will increase with concentration and increasing sodium percentages and will also depend upon soil conditions and management factors.

Only a few soil samples showed any appreciable salinity. However, those samples which contained more than 0.1 percent salt or had conductivities of greater than 4 millimhos in the saturation extract were from locations where rice had been damaged. Much more data are needed but these preliminary studies indicate that rice may be injured when the soil salinity approaches or exceeds these values.

CONSIDERATIONS FOR FUTURE WORK

1. The need for a limited water-resources program should be investigated. In conjunction with this, or as an immediate smaller independent study, periodic salinity and water-level measurements should be made on selected wells to determine if there is a significant change in salt concentration or depth of water with continuous pumping and with season, and if there is any trend over a period of years. Detailed water analyses would be needed only at the start of such a program, and when there is a marked change in total concentration as indicated by conductivity measurements.

2. There should be a continuing program for observation and correlation of the quality of irrigation waters with salt damage, salt content of soils, crops, and general soil types.

3. Salt-tolerance studies on rice including concentrations and types of salts in the soil and/or irrigation water which cause reductions in growth and yield.

4. A study of management factors. These should include season of planting, effect of climate, length of fallow or rotation period, alternate uses of land during rotation or fallow period, fertility, and nutritional programs.

Attachments - 4

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SOIL DATA

Sample No.	Description	Municipality	Reported Injury To Crop[1]	Date Sampled	Depth (Inches)	pH	SP[2]	EC_e[3]	Percent Salt[4]
S-1	Matanzas clay. Finca Peñalver southwest of Güira; 50 ft. south of W-23; fair bananas; saline water.	Güira	Slight	1/17/55	0-6	-	77	2.1	0.10
S-2	Same as S-1.	"	"	"	12-20	-	103	1.5	0.10
S-3	Matanzas clay. Finca Cuba Libre; 1/2 km. northeast of Las Cañas; plowed field.	Artemisa	None	1/13/55	0-12	-	68	0.3	0.01
S-4	Same as S-3.	"	"	"	12-20	-	77	0.2	0.01
S-5	Gavalan Swamp, edge. Southwest of Güira, Finca Peñalver; high organic matter, black and grey; salt types of grass and bushy vegetation.	Güira	-	1/17/55	0-8	-	180	4.0	0.46
S-6	Same as S-5. Yellowish clay with stones or Mocarrero.	"	-	"	12-20	-	118	2.1	0.16
S-7	Same as S-5. Yellowish to red mottled clay.	"	-	"	20-36	-	133	1.9	0.16
S-8	Gavalan clay. 150 yds. north of S-5, pasture.	"	-	"	0-16	-	87	1.5	0.08
S-9	Same as S 8	"	-	"	16-30	-	89	0.9	0.05

1/ None, slight, moderate, serious.
2/ Saturation percentage, USDA Handbook No. 60.
3/ Conductivity of saturation extract, millimhos per cm.
4/ Calculated from EC_e and SP assuming 1 millimho = 640 p.p.m. of total salts in extract.

Sample No.	Description	Municipality	Reported Injury To Crop	Date Sampled	Depth (Inches)	pH	SP	EC_e	Percent Salt
S-10	Maboa very fine sandy loam; shallow phase; Savannah pasture Compañia Territorial Carpinet, La Francia Central south of Los Palacios.	Los Palacios	-	1/12/55	0-6	-	34	0.2	<0.01
S-11	Same as S-10	"	-	"	6-10	5.2	24	0.3	<0.01
S-12	Maboa fine sandy loam; 1/2 km. south of rice elevator; Los Palacios, pasture.	"	-	"	0-8	5.4	36	0.3	0.01
S-13	Same as S-12. Subsoil.	"	-	"	8-	7.8	79	2.5	0.13
S-14	Herradura clay. 2-1/2 km. south of San Cristóbal; good sugar cane.	San Cristóbal	None	1/11/55	0-8	6.5	65	0.2	0.01
S-15	Maboa. 1 km. south of San Cristóbal sugar mill; good sugar cane.	"	"	"	0-12	5.8	91	0.4	0.02
S-16	Maboa. 22 km. south of Los Palacios and virgin land adjacent to new rice field.	Los Palacios	-	1/12/55	0-12	6.2	31	0.3	<0.01
S-38	Subsoil sample of S-16.	"	-	"	24-38	5.2	84	0.2	0.01
S-17	Very fine sandy loam, Sect. 20, cleared. Virgin Savannah. Compañia Dayaniguas south of Paso Real de San Diego.	"	-	1/19/55	0-6	5.4	35	0.7	0.02
S-40	Subsoil sample of S-17.	"	-	"	18-36	5.0	93	0.2	0.01
S-18	Same as S-17. Grades into fine sandy clay.	"	-	"	6-18	5.0	66	0.3	0.01
S-19	Camagüey black clay. Roul Lamar, Camagüey. Amorphous structure with iron concretions; rice with straight heads; flooded.	Camagüey Province	Straight Head	1/31/55	0-4	7.1	105	0.45	0.03

Sample No.	Description	Municipality	Reported Injury To Crop	Date Sampled	Depth (Inches)	pH	SP	EC_e	Percent Salt
S-20	Black clay. Roul Lamar, Camagüey. Rice with straight heads; flooded.	Camagüey Province	Straight Head	1/31/55	0-4	6.8	111	0.4	0.03
S-21	Same as S-20 but different field.	"	"	"	0-4	5.6	105	0.6	0.04
S-22	Rice field C-6. Savannah type soil. Cia Agrícola Miraflores, Cunagua Central; Enrique Rogue, Camagüey; flooded field; poor rice with straight heads.	"	"	2/4/55	0-4	7.3	24	0.55	0.01
S-23	Rice field. Black clay, Roul Lamar, Camagüey; poor rice; straight heads; field dry on surface.	"	"	2/3/55	0-4	6.3	69	1.1	0.05
S-24	Fine sandy loam, Punta Yaba, Enrique Tamneu, Camagüey; good young rice; field not flooded.	"	None	2/4/55	0-6	6.1	47	0.95	0.03
S-25	Same as S-24. Subsoil.	"	"	"	6-10	6.5	60	0.65	0.02
S-26	Rice field. Fine sandy loam. Punta Yaba, Enrique Tamneu, Camagüey; flooded field No. 21 near well; poor rice.	"	Straight Head	"	0-4	7.4	38	0.7	0.02
S-27	Coxville very fine sandy loam; shallow phase, Cia Agrícola de Caribe, south of Consolación del Sur, south end near sea; poor rice and abandoned.	Consolación	Serious	1/27/55	0-6	..	35	2.9	0.06
S-28	Same as S-27. Grey.	"	"	"	6-10	-	42	5.8	0.16
S-29	Same as S-27. Mottled yellowish-grey clay.	"	"	"	10-15	5.8	91	2.2	0.13

Sample No.	Description	Municipality	Reported Injury To Crop	Date Sampled	Depth (Inches)	pH	SP	EC_e	Percent Salt
S-30	Coxville fine sandy loam, poorly drained. Cia de Caribe, south of Consolación del Sur; poor rice yield; irrigated with water from Well #20, and 50 yds. to south of well.	Consolación	Serious	1/27/55	0-10	-	36	4.8	0.11
S-31	Same as S-30.	"	"	"	16-28	-	27	1.8	0.03
S-32	Same as S-30.	"	"	"	28-40	-	54	0.9	0.03
S-33	Coxville fine sandy loam, Cia de Caribe. Uncultivated, grass; 30 yds. south of Well #17.	"	-	"	0-10	5.2	35	1.1	0.02
S-34	Same as S-33.	"	-	1/27/55	18-30	4.9	66	0.6	0.03
S-35	Germinating rice, Cia de Caribe, south of Consolación, 50 yds. north of 1st lift pump on Herradura canal.	"	None to slight	"	0-2	5.9	38	3.0	0.07
S-36	Burned young rice. Cia de Caribe, south of Consolación del Sur; had been fertilized and flooded.	"	Serious	"	0-3	7.3	37	6.6	0.16
S-37	Virgin soil near road 19km. south of rice elevator. Los Palacios.	Los Palacios	-	1/12/55	0-10	4.9	47	0.2	0.01
S-38	Following S-16.	-	-	-	-	-	-	-	-
S-39	Salt flat approximately 16 km. south of San Cristóbal between road and village to east of road; little grass.	San Cristóbal	Barren	1/11/55	0-10	5.6	27	60	1.04
S-40	Following S-17.	-	-	-	-	-	-	-	-

Sample No.	Description	Municipality	Reported Injury To Crop	Date Sampled	Depth (Inches)	pH	SP	EC_e	Percent Salt
S-41	Rice field, Compañía Agrícola Dayaniguas south of Paso Real del San Diego; field irrigated two years with pump water; near uncultivated S-17; field wet but not flooded.	Los Palacios	Slight	1/19/55	0-8	5.5	38	4	0.10
S-42	Same as S-41.	"	-	"	15-24	4.9	103	0.5	0.03
S-43	Rice field 1/2 km. north of S-10, Compañia Territorial Carpinet, La Francia Central, Los Palacios; rice just germinating.	"	None	1/12/55	0-12	5.5	22	0.4	0.01
S-44	Maboa fine sandy loam, uncultivated pasture, Finca Galope, km. 78 between Artemisa and Candelaria; 1/2 km. southeast of Headquarters.	Candelaria	-	1/20/55	0-8	4.6	45	0.3	0.01
S-45	Same as S-44. Yellowish sandy clay.	"	-	"	12-18	4.9	29	0.1	<0.01
S-46	Coastal swamp; outer edge south of Alquízar on Guanímar Road; black muck; grass.	Alquízar	-	1/25/55	0-10	7.6	367	1.3	0.31
S-47	Same as S-46. Whitish and black marbled materials, calcareous.	"	-	"	10-22	7.6	235	1.3	0.20
S-48	Jucaro clay. Cia Arrocera Melina del Sur La Pronienta Rice Farm (Van Hule) near Batabanó; bare spot in rice field; salt on surface and some moss.	Batabanó	Bare, Serious	"	0-1/2	7.3	206	13	1.71
S-49	Same as S-48.	"	-	"	0-8	6.7	85	8	0.43

Sample No.	Description	Municipality	Reported Injury To Crop	Date Sampled	Depth (Inches)	pH	SP	EC_e	Percent Salt
S-50	Same as S-48. Yellowish, plastic, sticky clay.	Batabanó	-	1/25/55	12-18	7.8	104	6	0.40
S-51	Same as S-48. Buff to light red, plastic, sticky clay.	"	-	"	18-40	8.1	110	9	0.63
S-52	Jacuro clay. Bare spot in rice field 1/2 km. north and west of S-48 La Pronienta Rice Farm; moss on surface and possibly salt; bare spot.	"	Serious	"	0-1/2	7.1	88	5.5	0.31
S-53	Same as S-52.	"	-	"	0-4	5.9	83	1.8	0.10
S-54	Same as S-52.	"	-	"	4-12	5.6	71	1.9	0.09
S-55	Jacuro clay. Air strip west side of La Pronienta Rice Farm.	"	-	"	0-15	5.7	70	0.5	0.02
S-56	Same as S-55. Olive-yellow plastic clay.	"	-	"	15-40	7.0	104	0.6	0.04

W A T E R   D A T A

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC 1/ (mmhos.)	Total Salts 2/ (p.p.m.)
W-1	Well, irrigation. Finca San Pedro de la Rosa. 2 km. south of San Cristóbal.	1/11/55	12	21	-	0.9	531
W-2	Rio San Cristóbal. 4 km. south of San Cristóbal where road crosses the river.	"	-	-	7.7	0.45	266
W-3	Well, domestic. Finca Mayare 1 km. south of San Cristóbal mill, San Cristóbal.	"	20	42	7.3	1.0	590
W-4	Well, irrigation. Ferro Martinez Co. 4th well east of Headquarters, 17 km. south of San Cristóbal.	"	40	150	7.3	1.45	856
W-5 4/	Well, irrigation. Ferro Martinez Co. 5th well east of Headquarters, 17 km. south of San Cristóbal.	"	40	150	7.3	1.96	1114 3/
W-7	Windmill. Between the north-south road and village 25 km. south of San Cristóbal.	"	-	-	7.3	3.2	1888
W-8	Windmill. 6 km. south of rice elevator, Los Palacios.	1/12/55	40	-	7.5	0.3	177

1/ Conductivity in millimhos per cm.
2/ Calculated using factor 1 millimho = 590 parts per million of total salts which was obtained from data on the 37 detailed analyses.
3/ Direct determination by evaporation.
4/ Detailed analysis shown on separate sheet.

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-10 4/	Well, irrigation, No. 2. 1/4 km. east of Headquarters, Compañia Territorial Carpinet La Francia Central, south of Los Palacios.	1/12/55	54	178	7.3	1.12	664 3/
W-11	Well, irrigation, at corner of road to Headquarters and La Francia. Compañia Territorial Carpinet, south of Los Palacios.	"	60	150	7.4	0.8	472
W-12	Río Capellanias where highway crosses 4 km. east of Las Cañas	1/13/55	-	-	7.8	0.5	295
W-13 4/	Well, domestic and irrigation, Finca Cuba Libre 1/2 km. east of Las Cañas.	"	30	160	7.6	0.48	308 3/
W-14	Well, domestic and irrigation, 1 km. east of Bodega Flor de Kenaf, Artemisa.	"	50	120	7.5	0.5	295
W-15	Well, irrigation and domestic, 1/2 km. north of Las Cañas, Artemisa.	"	30	165	7.6	0.42	248
W-16	Well, irrigation, Finca Colmenar, 1 km. south of Artemisa-Los Baños Road southeast of Artemisa.	"	63	72	7.3	0.5	295
W-17	Well, irrigation, 1 km. south of No. 16 southeast of Artemisa.	"	66	75	7.5	0.55	325
W-18 4/	Well, irrigation, Finca Granal, 4 km. southeast of Artemisa.	"	66	90	7.4	0.53	324 3/
W-19	Well, irrigation, 7 km. southeast of Artemisa.	"	45	60	7.8	0.5	295
W 20	Well, irrigation, Finca Maravilla southeast of Artemisa and west of La Rancha.	"	35	45	7 6	0.53	313

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-21	Well, irrigation, Finca Maravilla 2 km. west of La Rancha, southeast of Artemisa.	1/13/55	-	-	7.7	0.5	295
W-22 4/	Boat channel in swamp near inner edge southwest of Güira and 1 km. south of sample 23 Finca Gavalan.	1/17/55	-	-	7.2	3.5	2042 3/
W-23 4/	Well, irrigation, Finca Peñalver southwest of Güira 1/2 km. west from corner 1st well.	"	8	12	7.5	4.4	2604 3/
W-24	Well, irrigation, 1/2 km. west of No. 23, Finca Peñalver, southwest of Güira.	"	8	12	7.5	2.8	1652
W-25	Well, irrigation, 1 km. west of No. 23, Finca Peñalver, southwest of Güira.	"	6	24	8.0	1.7	1003
W-26 4/	Well, irrigation, 1/2 km. east of Bodega Peñalver, southwest of Güira.	"	20	-	7.6	1.14	630 3/
W-27	Well, irrigation, at ranch headquarters at bend of road east of Bodega Peñalver, southeast of Güira.	"	13	40	7.6	1.3	767
W-28 4/	Well, irrigation, Finca Maximina, Ed Norrego, 1/4 km. east of Escuela 13 southwest of Güira.	"	24	70	7.7	0.70	396 3/
W-29	Well, irrigation, 2 km. south of Güira.	"	36	42	8.2	0.65	384
W-30	Well, irrigation, 1 km. southeast of Güira.	"	36	42	8.1	0.55	325
W-31 4/	Well, city, Güira, Finca Cafetal 1 km. north of town.	"	60	90	7.7	0.58	312 3/

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-32	Well, irrigation, Finca La Loma 4 km. north of Güira.	1/17/55	81	87	7.7	0.47	277
W-33	Well, irrigation, Finca Lourdes 8 km. north of Güira and 2 km. west.	"	-	-	-	0.48	283
W-34 4/	Well, irrigation, adjacent to road, Finca Anmali, 5 km. northeast of Güira and 1/4 km. west of Escuela 15.	"	82	140	7.3	0.46	294 3/
W-35	Well, irrigation, Finca Severana Jorge, northeast of Güira and 1/4 km. southwest of Escuela 21.	"	110	250	7.3	0.42	248
W-36	Well, irrigation, Finca Cabero, Pedro Valds, northeast of Güira and 1 km. northwest of Escuela 21.	"	125	145	7.4	0.47	277
W-37	Well, irrigation, in Section 15, Compañia Agrícola Dayaniguas, Paso Real de San Diego, southwest of Los Palacios.	1/19/55	31	95	7.6	1.5	885
W-38 4/	Río San Diego, Section 20, above intake for Compañia Agrícola Dayaniguas, Paso Real de San Diego.	"	-	-	-	2.39	1380 3/
W-39	Well, irrigation, Section 3, south of office. Surface elevation 17 meters - Compañia Agrícola Dayaniguas, Paso Real de San Diego.	"	45	131	-	1.86	1054 3/
W-40	Río Los Palacios at crossing of Central Highway.	"	-	-	7.9	0.4	236
W-41	Subsoil water, uncleared pasture Finca Galope, Portal Bros., 1 km. southeast of Headquarters Km. 78 between Artemisa and Candelaria.	1/20/55	-	1-1/2	5.5	0.12	71

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-42 4/	Well, irrigation, Finca Vinageras, Colonia Buena Vista 1 km. north and 1 km. east of Bodega San Pedro, southeast of Candelaria.	1/20/55	38	120	7.1	1.15	640 3/
W-43	Windmill. Finca Jejenens about 5 km. south of Bodega San Pedro, southeast of Candelaria.	"	-	-	7.1	1.25	738
W-45	Subsoil water at edge of coastal swamp about 4 km. north of Guanímar.	1/25/55	-	1-1/2	7.2	1.2	708
W-46	Subsoil water 150 yds. north of beach 1/4 km. east of Guanímar.	"	-	1-1/2	7.1	12	7080
W-47	Caribbean sea water, Guanímar.	"	-	-	8.1	60 (approx.)	39,400 (approx.)
W-48	Well, irrigation, Finca La Luz south side of Highway 7 km. northeast of Guanímar.	"	6	51	7.6	0.9	531
W-49	Well, domestic, Finca Breto north of Highway 8 km. northeast of Guanímar.	"	-	-	7.5	0.92	542
W 50	Well, irrigation, Finca Dominguito 3 km. south of Güira	"	31	85	7.5	0.75	443
W-51	Well, irrigation, Cia Arrocera Melina del Sur, Finca La Pronienta (Van Hule), north of Batabanó, 2nd well west of Headquarters.	"	18	162	7.1	1.8	1062
W-52 4/	Well, irrigation, 1st well west of Headquarters; saline rice field; Cia Arrocera Melina del Sur, Finca La Pronienta (Van Hule), north of Batabanó.	"	18	162	7.1	1.73	1018 3/

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-53	Well, irrigation, west side of rice field near air strip Cia Arrocera Melina del Sur, Finca La Pronienta (Van Hule), north of Batabanó.	1/25/55	-	-	7.1	1.5	885
W-54	Río Santa Clara at Central Highway east of Consolación del Sur.	1/27/55	-	-	7.7	0.6	354
W-55 4/	Río Hondo at diversion site for Cia Agrícola de Caribe, south of Consolación del Sur.	"	-	-	7.8	0.25	190 3/
W-56	Well, irrigation, No. 11, Cia Agrícola de Caribe, south of Consolación del Sur. Abandoned because of salt.	"	14	81	-	2.59	1582 3/
W-57	Well, irrigation, No. 15, Cia Agrícola de Caribe, south of Consolación del Sur.	"	32	140	7.0	1.4	826
W-58	Well, irrigation, No. 14, Cia Agrícola de Caribe, south of Consolación del Sur.	"	30	140	7.5	1.4	826
W-59	Well, irrigation, No. 17, Cia Agrícola de Caribe, south of Consolación del Sur	"	24	130	7.4	1.8	1062
W-60 4/	Well, irrigation, No. 20, Cia Agrícola de Caribe, south of Consolación del Sur. Poor rice reported to be caused by salinity	"	19	120	-	1.86	1098 3/
W 61	Well, irrigation, No. 17, Cia Agrícola de Caribe, south of Consolación del Sur.	"	30	120	7.3	2.2	1298
W-62	Canal at 1st lift pump from Herradura River, Cia Agrícola de Caribe, south of Consolación del Sur.	"	-	-	8.1	1.2	708

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-63 [4/]	Río Herradura at bridge above diversion canal, Cia Agrícola de Caribe, south of Consolación del Sur.	1/27/55	-	-	7.7	1.1	666 [3/]
W-64	Well, irrigation, No. 7 west of Herradura River, Cia Agrícola de Caribe, south of Consolación del Sur.	"	28	100	-	1.0	590
W-65	Run off water from rice field below pump No.7, Cia Agrícola de Caribe, south of Consolación del Sur.	"	-	-	8.1	1.0	590
W-66	Río del Media at Central Highway east of Enrique Herradura - (May flow into Herradura.)	"	-	-	7.9	0.85	501
W-67 [4/]	Río San Diego where it crosses Central Highway west of Los Baños turn off. (Compare with Sample No. 38).	"	-	-	-	0.60	458 [3/]
W-68	Run off water from rice field, Central Santa Marta, north of Santa Cruz del Sur, Camagüey. Sampled by Crandall.	1/28/55	-	-	6.4	1.3	767
W-69	Well, irrigation, new. Roul Lamar, Camagüey. Sampled by Crandall.	"	-	-	7.6	0.5	295
W-70	Well, irrigation, No. 3. Roul Lamar, Camagüey. Sampled by Crandall.	"	-	-	7.1	0.75	443
W-71	Well, irrigation, No. 5. Roul Lamar, Camagüey. Sampled by Crandall.	"	-	-	7.1	0.75	443
W-72	Wells, irrigation, Nos. 1 and 2 (canal), Cia Agrícola Miraflores, Central Cunagua, Camagüey. Sample submitted by Acunua.	2/1/55	-	-	6.8	0.85	502

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-73	Well, irrigation, No. 3, Cia Agrícola Miraflores, Central Cunagua, Camagüey. Sample submitted by Dr. Acunua.	2/1/55	-	-	6.8	0.7	413
W-74	Well, irrigation, No. 5, Cia Agrícola Miraflores, Central Cunagua, Camagüey. Sample submitted by Dr. Acunua.	"	-	-	6.8	0.7	413
W-75	Water standing on Field No. 10 from Well No. 4, Roul Lamar, Camagüey.	2/3/55	-	-	7.9	0.7	413
W-76 4/	Well, irrigation, No. 3, Roul Lamar, Camagüey.	"	28	130	7.4	0.76	430 3/
W-77 4/	Well, irrigation, 3D, Justicon Lamar, Camagüey.	"	43	150	7.1	0.55	294 3/
W-78	Well, irrigation, 2B, Justicon Lamar, Camagüey.	"	45	150	7.1	0.55	325
W-79	Well, irrigation, 3B, Justicon Lamar, Camagüey.	"	59	150	7.1	0.76	448
W-80	Water standing on rice field, Punta Yaba, Enrique Tamneu. River water from San Pedro, Camagüey.	2/4/55	-	-	7.9	1.35	797
W-81 4/	Well, irrigation, in Field 21, Enrique Tamneu, Punta Yaba, Camagüey.	"	43	130	7.1	0.7	380 3/
W-82 4/	Río San Pedro at pump lift, Enrique Tamneu, Punta Yaba, Camagüey.	"	-	-	7.8	1.3	712 3/
W-83	Well, irrigation, Finca La Lima, Punta Yaba, Camagüey, 2 km. west of No. 81.	"	43	130	7.0	0.75	443

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-84	Water, irrigation, from wells - canal near field. Cia Agrícola Miraflores, Central Cunagua, 70 km. northwest of Camagüey. Enrique Rogue.	2/4/55	-	-	7.6	0.85	502
W-85	Well, irrigation, Lot A. Central Najasa, Santa Marta, Camagüey. Sample submitted by Crandall.	2/7/55	-	-	7.2	0.8	472
W-86 4/	Well, irrigation, Lot D. Central Najasa, Santa Marta, Camagüey. Sample submitted by Crandall.	"	-	-	7.0	1.2	702 3/
W-87 4/	Laguna Grande (lake), Finca Carojal, south of Central Highway at Km. 75 between Artemisa and Candelaria.	2/15/55	-	-	-	0.2	106 3/
W-88 4/	Well, irrigation, Finca Carojal 4 km. south of Laguna Grande and Km. 75.	"	3	145	-	1.0	582 3/
W-89	Spring, Finca Ojo de Agua, Km. 73 between Artemisa and Candelaria.	"	-	-	-	0.72	425
W-90 4/	Well, irrigation, No. 3, Finca Galope (Portal), Km. 78 between Artemisa and Candelaria.	2/16/55	72	110	7.2	0.55	312 3/
W-91	Well, irrigation, No. 1, Finca Galope (Portal), Km. 78 between Artemisa and Candelaria.	"	110	150	7.3	0.58	342
W-92 4/	Well, irrigation, No. 2. Ramon (Mommie) Acosta. South of Herradura.	"	38	102	7.3	0.9	312 3/

Sample No.	Description	Sampling Date	Depth To Water (Ft.)	Depth Of Well (Ft.)	pH	EC (mmhos.)	Total Salts (p.p.m.)
W-93 [4/]	Well, irrigation, No. 3, Sanchez, adjacent to Acosta, and south of Herradura.	2/16/55	57	132	7.3	1.3	726 [3/]
W-94	Well, irrigation, No. 2, Sanchez, adjacent to Acosta, and south of Herradura.	"	57 (Approx.)	132	7.3	0.9	506 [3/]
W-95 [4/]	Well, irrigation, No. 1, Sanchez, adjacent to Acosta, and south of Herradura.	"	57 (Approx.)	132	7.5	0.8	439 [3/]
W-97	Río San Pedro at site of pump lift for Acosta. South of Herradura.	"	-	-	..	2.0	1209 [3/]
W-98	Well, irrigation, Augustine de La Guardia. Near Acosta and south of Herradura.	"	-	-	7.4	2.3	1357
W-100 [4/]	Well, irrigation, Jose Antonio Mestre, Arrocera Limones, west of Mendoza and Guane.	2/17/55	90	110	7.2	1.6	937 [3/]
W-101	Creek or small river at north side of Arrocera Limones Mendoza.	"	-	-	7.5	0.45	266
W-102 [4/]	Río Guyaguateje at Central Highway 2 km. east of Guane.	"	-	-	7.7	0.4	208 [3/]
W-103	Well, irrigation, Rinconada well, Central Gomez-Mena, south of San Nicolas.	2/18/55	50	70	7.4	0.9	531
W-104 [4/]	Well, irrigation, No. 2, Jose Pino, Central Gomez-Mena, south of San Nicolas.	"	-	-	7.3	0.8	460 [3/]

Transcribed by JTH

Checked by JTH-MGK

Date 2-14-55

United States Department of Agriculture
Agricultural Research Service
Farm and Land Management Research
Soil and Water Conservation Research Branch
Soil and Plant Relationships Section
U. S. Salinity Laboratory
Riverside, California

Rubidoux Unit Table 8/55

February 14, 1955

ANALYSES OF WATER SAMPLES FROM CUBA

	Method No.										
Sample Number		22914	22915	22916	22917	22918	22919	22920	22921	22922	22923
Collector's Number		5	10	13	18	22	23	25	28	31	34
Conductivity, $EC \times 10^6$ @ 25°C.	(72)	1960	1120	485	533	3530	4440	1140	701	582	452
Sodium-adsorption-ratio (SAR)	(20b)	4.4	2.3	.3	.4	9.1	13	2.3	.8	.5	.4
Soluble-sodium-percentage (SSP)		50	38	9	10	65	71	38	19	14	12
Boron B p.p.m.	(73b)	.1	.1	.07	.08	.3	.5	.2	.1	.06	.05
Dissolved solids t.a.f.	(74)	1.52	.90	.42	.44	2.78	3.54	.86	.54	.42	.31
Dissolved solids p.p.m.	(74)	1114	664	308	324	2042	2604	630	396	312	228
pH	(75)	8.2	8.3	8.4	8.1	8.2	8.1	8.0	8.2	8.4	8.3
Calcium + Magnesium Ca+Mg meq./l.	(79)	9.45	6.77	4.78	5.27	11.44	11.54	6.67	5.87	5.37	4.18
Calcium Ca "	(79)	5.18	5.18	4.26	4.43	6.42	5.91	4.53	4.70	4.63	3.60
Magnesium Mg "	(79)	4.33	1.54	.48	.69	5.08	5.49	2.03	1.03	.55	.55
Sodium Na "	(80b)	9.62	4.16	.46	.58	21.8	30.8	4.23	1.44	.85	.58
Potassium K "	(81c)	.19	.08	.05	.04	.44	.80	.31	.08	.04	.04
Sum of Cations		19.26	11.01	5.29	5.89	33.7	43.1	11.21	7.39	6.26	4.80
Carbonate CO_3 meq./l.	(82)	0	0	0	0	0	0	0	tr	.20	.20
Bicarbonate HCO_3 "	(82)	5.50	4.40	4.25	4.95	4.45	4.90	4.85	4.75	4.51	3.75
Sulfate SO_4 "	(83)	1.37	.62	.12	.17	2.77	3.75	.53	.33	.27	.23
Chloride Cl "	(84)	12.55	5.90	.50	.42	26.85	34.80	5.45	1.75	.85	.55
Fluoride F "	(85)	—	—	tr	—	—	—	—	—	tr.	—
Nitrate NO_3 "	(86a)	.03	.05	.27	.17	.03	.14	.17	.30	.19	.20
Sum of Anions		19.45	10.97	5.14	5.71	34.10	43.59	11.00	7.13	6.02	4.93

	Method No.											
Sample Number		22924	22925	22926	22927	22928	22929	22930	22931	22932	22933	22934
Collector's Number		38	39	42	52	55	56	80	63	64	67	
Conductivity, $EC \times 10^6$ @ 25°C.	(72)	2390	1860	1150	1730	248	2590	1860	1100	1050	597	717
Sodium-adsorption-ratio (SAR)	(20b)	6.3	4.7	1.8	3.4	.8	4.8	3.3	2.7	2.3	.5	.5
Soluble-sodium-percentage (SSP)		59	53	31	43	31	49	41	43	39	13	11
Boron B p.p.m.	(73b)	.2	.2	.1	.2	.07	.1	.06	.06	.06	.04	.09
Dissolved solids t.a.f.	(74)	1.88	1.43	.87	1.38	.26	2.15	1.49	.91	.84	.62	.64
Dissolved solids p.p.m.	(74)	1380	1054	640	1018	190	1582	1098	666	620	458	468
pH	(75)	8.2	8.3	8.4	7.7	7.8	7.7	7.8	8.2	7.9	8.1	7.7
Calcium + Magnesium Ca+Mg meq./l.	(79)	9.25	8.26	8.16	9.95	1.69	12.54	10.35	6.07	6.27	5.67	6.96
Calcium Ca "	(79)	5.29	4.74	5.05	5.84	1.27	6.35	5.46	4.53	3.74	4.63	6.21
Magnesium Mg "	(79)	3.74	3.36	2.88	4.09	.38	6.25	4.81	1.54	2.61	1.13	.76
Sodium Na "	(80b)	13.5	9.62	3.74	7.60	.78	12.0	7.42	4.66	4.07	.86	.89
Potassium K "	(81c)	.30	.28	.09	.20	.05	.14	.11	.11	.08	.05	.08
Sum of Cations		23.0	18.16	11.99	17.75	2.52	24.7	17.88	10.84	10.42	6.58	7.93
Carbonate CO_3 meq./l.	(82)	0	0	tr	0	0	0	0	0	0	.24	0
Bicarbonate HCO_3 "	(82)	3.94	4.54	5.62	7.40	1.62	4.14	4.02	4.14	4.00	3.01	6.45
Sulfate SO_4 "	(83)	2.59	1.77	.95	1.71	.23	.69	.51	1.27	.40	2.84	.54
Chloride Cl "	(84)	16.68	11.90	5.20	8.70	.50	19.90	13.20	5.40	5.84	.55	.70
Fluoride F "	(85)	—	—	—	—	—	—	—	—	—	—	.01
Nitrate NO_3 "	(86a)	.02	.02	.04	.05	tr	tr	tr	tr	tr	.01	tr.
Sum of Anions		23.23	18.23	11.81	17.86	2.35	24.73	17.73	10.81	10.24	6.65	7.70

Sample Number	Collector's Number	Location and Description
22914	5	IRRIGATION WELL, Feno Martinez Company, 10 miles south of San Cristobal, Cuba, 5th well east of headquarters. Used for rice. Depth, 150 feet; depth to water, 40 feet. Collected Jan. 11, 1955, by A. D. Ayers.
22915	10	IRRIGATION WELL, No. 2, Compania Territorial Carpinet, La Francia Central, Los Palacios, Cuba, 0.25 km. east of headquarters. Depth, 178 feet; depth to water, 54 feet; discharge, 3000 gpm. Collected Jan. 12, 1955, by A. D. Ayers.
22916	13	IRRIGATION AND DOMESTIC WELL, Finca Cuba Libre, 0.25 mile east of Las Canos, Cuba. Depth, 160 feet; depth to water, 30 feet. Collected Jan. 13, 1955, by A. D. Ayers.
22917	18	IRRIGATION WELL, Finca Granal, 2 miles southeast of Artemisa, Cuba. Depth, 90 feet; depth to water, 66 feet. Excellent tomatoes, peppers, bananas, okra, etc. Collected Jan. 13, 1955, by A. D. Ayers.
22918	22	WATER FROM CHANNEL at edge of Gavalan Swamp, end of road southeast of Guira, near Penalver, Cuba. Collected Jan. 17, 1955, by A.D.Ayers.
22919	23	IRRIGATION WELL, Finca Penalver, Cuba. 0.4 km. west from corner. Depth, 12 feet; depth to water, 8 feet. Collected Jan. 17, 1955, by A. D. Ayers.
22920	26	IRRIGATION WELL, 0.25 mile east of Bodega Penalver, southwest of Guira, Cuba. Depth to water, 20 feet. Collected Jan. 17, 1955, by A. D. Ayers.
22921	28	IRRIGATION WELL, Finca Maximina, Eduardo Norrego, 1/8 mile east of Escuela 13 and south of Guira, Cuba. Depth 70 feet; depth to water, 20 feet. Collected Jan. 17, 1955, by A. D. Ayers.
22922	31	CITY WATER SUPPLY, Finca el Cafetal, Guira, Cuba. Collected Jan. 17, 1955, by A. D. Ayers.

Sample Number	Collector's Number	Location and Description, cont'd.
22923	34	IRRIGATION WELL, Finca Anmali, 1/8 mile west of Escuela 15 and 3 miles northeast of Guira, Cuba. Adjacent to highway. Depth, 142 feet; depth to water, 82 feet. Collected Jan. 17, 1955, by A. D. Ayers.
22924	38	RIO SAN DIEGO, Compana Agricola Dayaniguas, Paseo Real de San Diego, Cuba, just above lift pump location. Collected Jan. 19, 1955, by A. D. Ayers.
22925	39	IRRIGATION WELL No. 3, Compana Agricola Dayaniguas, Cuba, south of headquarters. Surface elevation 17 meters. Depth, 131 feet; depth to water, 45 feet. Collected Jan. 19, 1955, by A. D. Ayers.
22926	42	IRRIGATION WELL, Finca Vinagerae, Colonia Buena Vista, Central Andona, 1 1/2 miles northeast of Bodega San Pedro, Cuba. Depth, 120 feet; depth to water, 40 feet. Collected Jan. 20, 1955, by A. D. Ayers.
22927	52	IRRIGATION WELL, Cia Arronocra, Melena del Sur, La Pionienta Rice Farm south of La Coohara and almost to Batabano, Cuba. Depth, 162 feet; depth to water, 18 feet. Saline spots in rice field after second crop. Collected Jan. 25, 1955, by A. D. Ayers.
22928	55	RIO HONDO, at diversion site Cia Agricola de Caribe, south of Consolacion del Sur, Pinar del Rio, Cuba. Flow approximately 30,000 gpm. Collected Jan. 1955, by A. D. Ayers.
22929	56	IRRIGATION WELL No. 11. Cia Agricola de Caribe, Cuba. Depth, 81 feet; depth to water, 14 feet; ground level approximately 18 feet. Poor rice and well to be abandoned. Collected Jan. 27, 1955, by A. D. Ayers.
22930	80	IRRIGATION WELL No. 20. Cia Agricola de Caribe, Cuba. Depth, 120 feet; depth to water 19 feet. Poor rice. Collected Jan. 27, 1955, by A. D. Ayers.

Sample Number	Collector's Number	Location and Description, cont'd
22931	63	RIO HERRADURA, just above diversion where road crosses from headquarters of Cia Agricola de Caribe, Cuba. Collected Jan. 27, 1955, by A. D. Ayers.
22932	64	IRRIGATION WELL No. 7, Cia Agricola de Caribe, between headquarters and Rio Herradura, Cuba. Depth, 100 feet; depth to water, 28 feet. Collected Jan. 27, 1955, by A. D. Ayers.
22933	67	RIO SAN DIEGO where it crosses the central highway west of Los Banos turnoff, Cuba. Collected Jan. 27, 1955, by A. D. Ayers.
22934		EXPERIMENT STATION WATER SUPPLY. Santiago de la Vegas, Cuba. Collected Jan. 1955, by A. D. Ayers.

Methods of Analysis

Methods used for the analysis of these samples are described in detail in the U. S. Dept. of Agr. Handbook No. 60, entitled "Diagnosis and improvement of saline and alkali soils". The method numbers are given above.

Analyzed by: Hatcher, Blair, Keyes, Akin

Reported by: L. V. Wilcox/mmt

Reported to: Dr. Alvin D. Ayers (4 copies)
c/o Mr. John Johnston
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U.S. Salinity Laboratory File (1 copy)

Transcribed by m.g.k.
Checked by JTH - mgk
Date April 20, 1955

United States Department of Agriculture
Agricultural Research Service
Farm and Land Management Research
Soil and Water Conservation Research Branch
Section of Soils and Plant Relationships
U. S. Salinity Laboratory
Riverside, California

Rubidoux Unit Table 24/55

April 13, 1955

ANALYSES OF WATER SAMPLES FROM CUBA

	Method No.																
Sample Number		23015	23016	23017	23018	23019	23020	23021	23022	23023	23024	23025	23026	23027	23028	23029	23030
Collector's Number		W-76	W-77	W-81	W-82	W-86	W-87	W-88	W-90	W-92	W-93	W-94	W-95	W-97	W-100	W-102	W-104
Conductivity, $ECx10^6$@25°C.	(72)	763	554	681	1290	1220	151	1040	549	900	1250	877	785	2020	1600	340	779
Sodium-adsorption-ratio (SAR)	(20b)	.8	.3	.6	2.3	1.2	.9	2.2	.6	2.2	2.9	.7	1.9	4.8	5.1	.3	1.2
Soluble-sodium-percentage (SSP)		18	7	14	35	22	42	38	15	40	44	16	38	53	59	11	26
Boron B p.p.m.	(73b)	.1	.06	.03	.1	.06	.03	.03	.05	.03	.06	.06	.06	.06	.06	.03	trace
Dissolved solids t.a.f.	(74)	.58	.40	.52	.97	.95	.14	.79	.42	.69	.99	.69	.60	1.64	1.27	.28	.63
Dissolved solids p.p.m.	(74)	430	294	380	712	702	106	582	312	508	726	506	439	1209	937	208	460
pH	(75)	8.3	8.1	8.4	8.4	8.0	7.2	8.1	8.2	8.3	8.0	8.3	8.1	7.8	8.1	8.0	8.3
Calcium + Magnesium Ca+Mg meq./l.	(79)	6.63	5.69	6.41	8.66	10.15	.71	6.21	4.90	5.21	6.61	7.56	4.70	8.56	5.89	3.10	5.77
Calcium Ca "	(79)	3.52	4.04	4.10	4.58	5.95	.56	3.81	3.58	3.56	4.80	4.39	3.28	5.73	4.39	2.39	4.53
Magnesium Mg "	(79)	3.11	1.65	2.31	4.08	4.20	.21	2.31	1.22	1.48	1.69	3.17	1.38	2.70	1.48	.70	1.24
Sodium Na "	(80b)	1.48	.46	1.01	4.71	2.80	.56	3.89	.89	3.48	5.28	1.42	2.90	9.88	8.76	.39	2.09
Potassium K "	(81e)	.06	.04	.04	.17	.07	.65	.08	.04	.08	.10	.05	.09	.28	.12	.03	.06
Sum of Cations		8.17	6.19	7.46	13.54	13.02	1.32	10.18	5.83	8.77	11.99	9.03	7.69	18.72	14.77	3.52	7.92
Carbonate CO_3 meq./l.	(82)	.32	trace	.40	.60	trace	0	trace	.20	.20	0	.44	trace	0	trace	0	.32
Bicarbonate HCO_3 "	(82)	6.03	5.65	6.20	6.55	7.85	.51	4.30	4.40	3.55	4.65	7.15	3.61	1.10	2.73	2.55	5.28
Sulfate SO_4 "	(83)	.28	.11	.15	1.05	.44	.10	.55	.22	.52	.81	.18	.45	2.26	.87	.63	.61
Chloride Cl "	(84)	1.65	.35	.75	5.15	4.60	.65	5.25	.95	4.50	6.95	1.40	3.50	15.00	11.10	.45	1.95
Fluoride F "	(85)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Nitrate NO_3 "	(86a)	trace	trace	.04	.01	0	trace	trace	.02	.01	.02	.32	.02	.06	.01	.01	.02
Sum of Anions		8.29	6.12	7.55	13.37	12.90	1.27	10.11	5.80	8.79	12.44	9.50	7.59	18.43	14.72	3.65	8.19

Sample Number	Collector's Number	Location and Description
23015	W-76	IRRIGATION WELL NO.3. West of Vertientes in Camagüey Province, Cuba. Depth, 28/130. Owner Raul Lamar. Sample collected February 3, 1955, by A. D. Ayers.
23016	W-77	IRRIGATION WELL NO. 3D. West of Vertientes, in Camagüey Province, Cuba. Depth, 43/150. Owner Justico Lamar. Sample collected Feb. 3, 1955, by A. D. Ayers.
23017	W-81	IRRIGATION WELL IN FIELD NO. 21. Punta Yaba, southwest of Vertientes, Camagüey Province, Cuba. Depth 43/130. Owner, Enrique Tamneu. Sample collected February 4, 1955, by A. D. Ayers.
23018	W-82	RIO SAN PEDRO. At pump lift for diversion to Enrique Tamneu ranch, Punta Yaba, southwest of Vertientes, Camagüey Province, Cuba. River flow only very slightly higher than the usually low flow for this winter period. Recent showers. Sample collected February 4, 1955, by A. D. Ayers.
23019	W-86	IRRIGATION WELL, LOT D. Arrocera Majasa, Central Santa Marta, near Santa Cruz del Sur, Camagüey Province, Cuba. Sample submitted by Central on February 7, 1955.
23020	W-87	LAGUNA GRANDE, Finca Carejal, south of Central Highway at Km. 75, between Artemisa and Candelaria, Pinar del Río Province, Cuba. Sample collected February 15, 1955, by A. D. Ayers.
23021	W-88	IRRIGATION WELL, Finca Carojal, 2 miles south of Laguna Grande, west side of road near rice shed, Pinar del Río Province, Cuba. Depth, 3/145. Sample collected February 15, 1955, by A. D. Ayers.

Sample Number	Collector's Number	Location and Description, cont'd.
23022	W-90	IRRIGATION WELL NO. 3. Finca Galepe, Km. 78, between Artemisa and Candelaria, Pinar del Río Province, Cuba. Depth, 72/110. Sample collected February 16, 1955, by A. D. Ayers.
23023	W-92	IRRIGATION WELL NO. 2. South of Herradura, Pinar del Río Province, Cuba. Depth, 38/102. Owner, Ramon Acosta. Sample collected February 16,1955, by A. D. Ayers. Well pumped only 10 minutes prior to sampling.
23024	W-93	IRRIGATION WELL NO. 3. South of Herradura, Pinar del Río Province, Cuba. On Sanchez ranch, adjacent to property of Ramon Acosta. Depth, 57/132. Sample collected February 16, 1955, by A. D. Ayers.
23025	W-94	IRRIGATION WELL NO. 2. South of Herradura, Pinar del Río Province, Cuba. On Sanchez ranch, adjacent to property of Ramon Acosta. Depth, approximately 60/130. Sample collected February 16, 1955, by A. D. Ayers.
23026	W-95	IRRIGATION WELL NO. 1. South of Herradura, Pinar del Río Province, Cuba. Sanchez ranch near Acosta property. Approximate depth, 60/130. Sample collected February 16, 1955, by A. D. Ayers.
23027	W-97	RIO SAN PEDRO, south of Herradura and Paso Real de San Diego, Pinar del Río Province, Cuba. At site of pump lift for Acosta ranch. Sample collected February 16, 1955, by A. D. Ayers.
23028	W-100	IRRIGATION WELL, Arrocero Limones, west of Guane and Mendoza, Pinar del Río Province, Cuba. Depth 90/110. Owner, Jose Antonio Mestre. Sample collected February 17, 1955, by A. D. Ayers.

Sample Number	Collector's Number	Location and Description, cont'd.
23029	W-102	RIO GUYAGUATEJE at Central Highway, 2 Km. east of Guane, Pinar del Río Province, Cuba. Very low flow. Sample collected February 17, 1955, by A. D. Ayers.
23030	W-104	IRRIGATION WELL NO. 2. Central Gomez-Mena, San Nicolas, Habana Province, Cuba. Approximate depth, 50/70. Owner, Jose Pine. Sample collected February 18, 1955, by A. D. Ayers.

Methods of Analysis

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Previous tables of this series: 8/55.

Analyzed by: Hatcher, Keyes, Blair, Akin. Reported by: L.V.Wilcox/mmt

Reported to: Dr. Alvin D. Ayers (4 copies)
U.S.Salinity File (1 copy)